

**70135**  
Ilmenite Basalt  
446 grams



Figure 1: Photo of 70135. Sample is about 10 cm across. NASA S72-56380. Note the dirty surface.

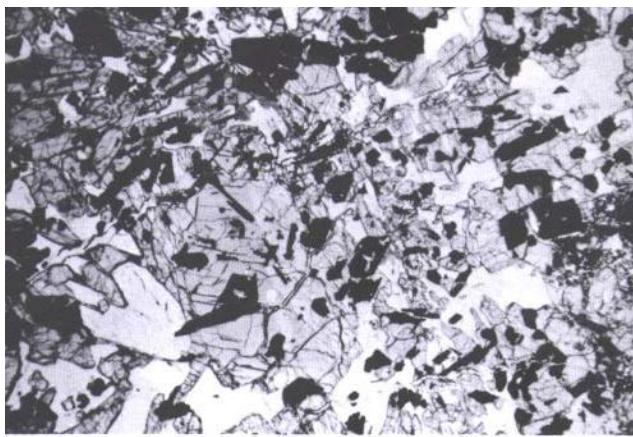


Figure 2: Photomicrograph of thin section of 70135 from Wolfe et al. (1981). Field of view is 6 mm.

### **Introduction**

70135 was collected from Geophone Rock, along with other smaller pieces (70136 to 70158) (figure 3). Geophone Rock was about 3 meters high and was

located at the ALSEP station about 150 m from the LM. It is a vesicular high-Ti basalt typical of the Apollo 17 site with a crystallization age of about 3.7 b.y. and an exposure age of about 110 m.y.

Part of the interest in Geophone Rock was that it was expected that it would be covered with the mysterious “dark mantle”, but the astronauts were unable to recognize such (see transcript).

### **Petrography**

Brown et al. (1975) and others described 70135 as “plagioclase-poikilitic” (figure 4). Small olivine grains are found poikilitically enclosed in pyroxene and plagioclase. Rare armalcolite is found poikilitically enclosed in pyroxene. Roedder and Weiblen (1975) studied the silicate melt inclusions found trapped in ilmenite. Metallic iron and troilite are found in the mesostasis.



Figure 3: Geophone Rock, located at the ALSEP site, about 150 meters from the LM, is ~ 3 meters high. Samples 70135 to 70155 were from the area indicated. NASA photo S17-147-22536.

LMP Bag 10 echo (70135) is a sample of a very large boulder that's just beyond geophone 3. It's the same kind of rock I saw near the LM – and the Gabbro – I'm beginning to lean towards 50% plagioclase, though. I see no clear alignment of plagioclase or pyroxene in it. That's the one with the parting in it. It looks as if – integrating what I've seen here and over at the big rock – the geophone rock – that the layering or the foliation or the parting, whichever it is, is the result of variations in vesicle concentrations. The sample 10 echo (70135) is a sample of the more coarsely vesicular rock. I could not get one of the finer – more finely or nonvesicular fragments. But I got pictures of it.

Neal et al. (1989) and Neal and Taylor (1993) reported on the mineralogy and petrography of the smaller samples from this same basaltic boulder.

### Mineralogy

**Pyronene:** Although mineral chemistry for 70135 is unknown, Neal et al. (1989) and Neal and Taylor (1993) reported pyroxene compositions of some of the smaller fragments (summarized in figure ) that were also sampled from Geophone Rock.

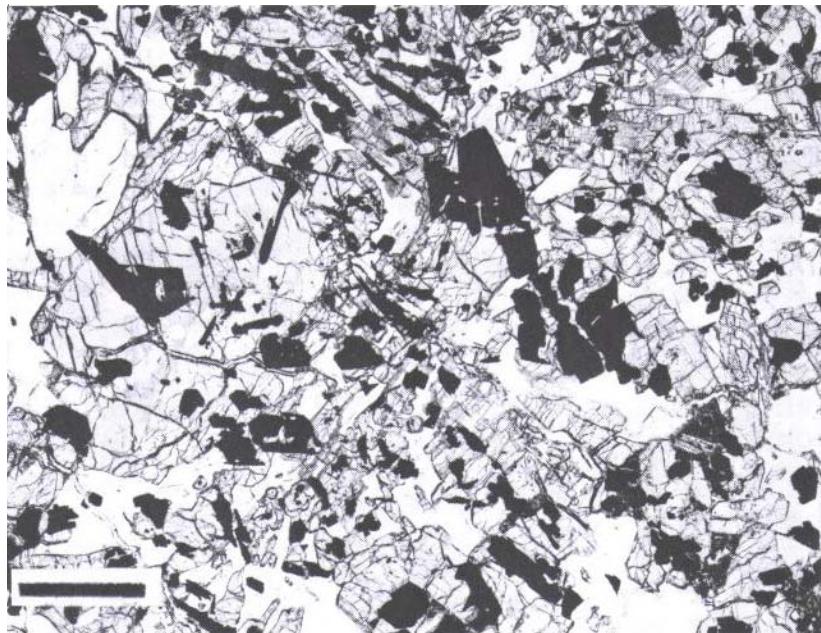


Figure 4: Photomicrograph of thin section of 70135 (from Lofgren and Lofgren 1981). Scale is 1 mm.

**Opaques:** El Goresy and Ramdohr (1975) studied the subsolidus reduction of ilmenite and chromite. Analyses of metallic iron are not given.

**Rutile:** El Goresy and Ramdohr (1975) gave analyses of rutile in 70135 (table 4) and noted that Zr was enriched. Neal et al. (1989) also reported rutile in 70138. It apparently forms by exsolution from early formed ilmenite.

### Chemistry

Rhodes et al. (1976), Laul et al. (1974), Rose et al. (1975), Shih et al. (1975), Korotev and Haskin (1975), and Dickinson et al. (1989) found widely variable results (table 1). Something is wrong (figure 7). Either the samples included the soil seen attached in figure 1, or there was a mistake in sample numbers. Korotev and Haskin (1975) discussed the sample size limitations. The only satisfactory resolution would be to prepare a large clean sample, and create a powder for carefully planned analyses.

### Mineralogical Mode of 70135

	Roedder and Weiblen 75	Brown et al. 1975
Olivine	3.8	2.8
Pyroxene	51.6	46.2
Plagioclase	23	28.4
Oxides	19.4	21.9
Metal	0.2	
Silica	0.6	0.3
Mesostasis	1.4	0.4

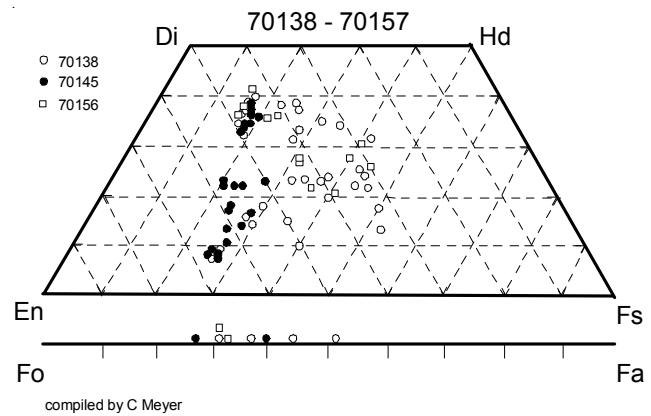


Figure 5: Composition of olivine and pyroxene in samples of Geophone Rock (from Neal and Taylor 1993).

Ma et al. (1979) and Neal et al. (1990) analyzed the smaller fragments also chipped from Geophone Rock (table 2). These analyses were consistent, and may give the best value for Geophone Rock. It is interesting

### (70138)      (70139)      (70145)

	Neal et al. 1989	Neal et al. 1989	Neal et al. 1989
	3	2.5	2
	49.7	35.8	42.5
	22.2	41.6	32.5
	24.1	15.8	24.1
	1	2.4	1.3
		1.9	

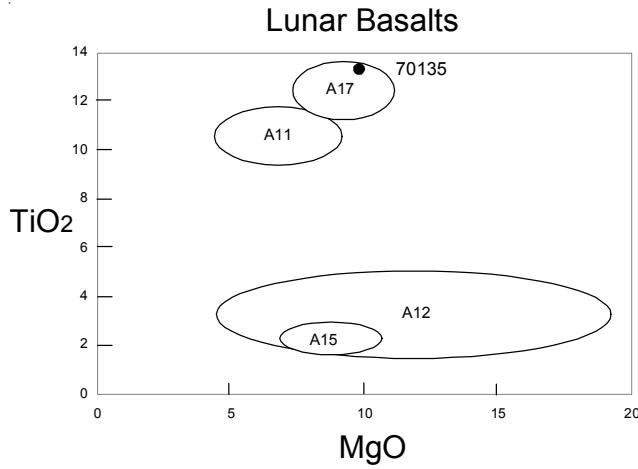


Figure 6: Chemical composition of Apollo basalts with 70135.

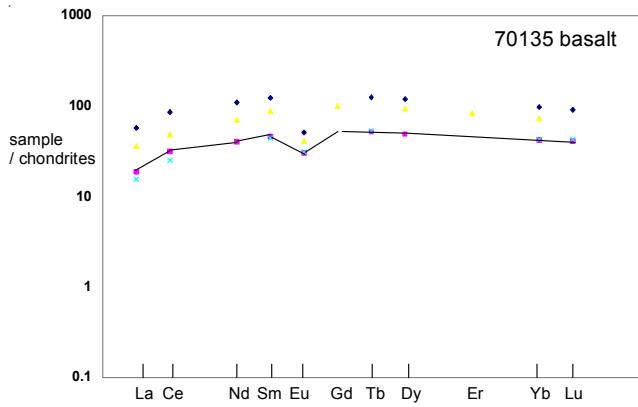


Figure 7: Normalized rare-earth-element diagram for splits of Geophone Rock (table 1 and 2).

to note that classification of these basalt samples varied from type A to type B!

Gibson et al. (1976) reported 1680 ppm sulfur in 70135. Jovanovic and Reed (1975 on) reported on halogens, Ru and Os.

### Radiogenic age dating

Nyquist et al. (1975, 1979) dated 70135 by Rb-Sr and Sm-Nd internal mineral isochrons (figures 9 and 10). Paces et al. (1991) reported an age for 70139 from the same rock, as well as whole rock data for 70138 (also from Geophone Rock).

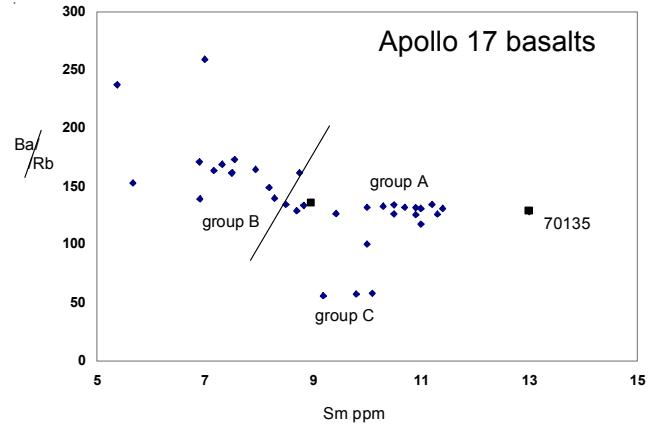


Figure 8: Trace element diagram for Apollo 17 basalts.

### Cosmogenic isotopes and exposure ages

Cosmic-ray induced activity of  $^{22}\text{Na}$  = 33 dpm/kg.,  $^{26}\text{Al}$  = 38 dpm/kg.,  $^{54}\text{Mn}$  = 56 dpm/kg.,  $^{56}\text{Co}$  = 56 dpm/kg. and  $^{46}\text{Sc}$  = 32 dpm/kg. was determined by radiation counting of 70135 (O'Kelley et al. 1974). Interestingly this high activity could be traced to intense bombardment by solar wind protons on Aug 4-9, 1972, prior to the Apollo 17 mission.

The exposure age by  $^{81}\text{Kr}$  was reported as 106 m.y. by Arvidson et al. (1974).

### Other Studies

Brecher (1977) and Cisowski (1983) reported on the magnetic properties of 70135. This magnetic data is interesting in light of the reduced iron found in this rock.

### Processing

A small slab (1 cm thick) was cut from one end of 70135 (figure 11).

Table 4: Rutile (ElGoresy and Ramdohr 1975)

TiO <sub>2</sub>	97.8	98.9	97	98.6	97.9	98.3	99.5	99.8
FeO	0.93	0.81	0.72	0.59	0.72	0.86	0.79	0.81
MgO	0.04	0.04	0.03	0.06	0.03		0.05	0.07
Cr <sub>2</sub> O <sub>3</sub>	0.23	0.23	0.38	0.23	0.38	1.54	0.27	0.34
ZrO <sub>2</sub>	0.82	0.65	0.64	0.32	1.09	1.31	0.84	0.91

**Table 1. Chemical composition of 70135.**

reference weight	Rhodes76	Laul 74 231 mg	Rose75	Duncan75	Shih75 Wiesmann 76	Dickinson89	O'Kelly Eldridge74	Korotev75 averages fines	Korotev75 coarse
SiO <sub>2</sub> %	37.85	(a)	38.6	(c ) 37.68	(a)				
TiO <sub>2</sub>	13.34	(a) 13.8	(b) 13.33	(c ) 13.83	(a)				
Al <sub>2</sub> O <sub>3</sub>	7.34	(a) 7	(b) 8.88	(c ) 7.53	(a)				
FeO	19.68	(a) 21.8	(b) 18.97	(c ) 19.74	(a)	14.7	16.3	(b)	(b)
MnO	0.29	(a) 0.27	(b) 0.29	(c ) 0.26	(a)				
MgO	9.29	(a) 9	(b) 9.45	(c ) 10	(a)				
CaO	10.18	(a) 8.7	(b) 9.82	(c ) 9.8	(a)	11.5	10.4	(b)	
Na <sub>2</sub> O	0.34	(a) 0.4	(b) 0.36	(c ) 0.4	(a)	0.31	0.34	(b)	
K <sub>2</sub> O	0.09	(a) 0.11	(b) 0.06	(c ) 0.051	(a)	0.09	(d)	0.06	(e)
P <sub>2</sub> O <sub>5</sub>	0.07	(a)	0.04	(c ) 0.077	(a)				
S %	0.15	(a)		0.191	(a)				
<i>sum</i>									
Sc ppm		82	(b) 86	(c )	81.7	(d) 77	75	(b)	
V		120	(b) 65	(c ) 127	(a)	339	480	(b)	
Cr	3760	(a) 3462	(b) 3350	(c ) 4351	(a)	4300	3700	(b)	
Co		20	(b) 29	(c ) 20	(a) 16.6	(d) 15	17	(b)	
Ni		<1	(c )						
Cu		32	(c )						
Zn		4.1	(c )						
Ga		7	(c )			16		(b)	
Ge ppb						1	2	(b)	
As									
Se									
Rb		<1	(c ) <1.4	(a)	0.819	(d)			
Sr		152	(c ) 165	(a)	186	(d)			
Y		99	(c ) 103	(a)					
Zr		230	(c ) 299	(a)	319	(d)	190	(b)	
Nb		<10	(c ) 26.3	(a)					
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb									
In ppb									
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm									
Ba	210	(b) 210	(c ) 113	(a)	105	(d)	86	(b)	
La	12.6	(b) <10	(c )		8.49	(d) 3.8	7.5	(b)	
Ce	52	(b)			29.4	(d) 12	25	(b)	
Pr									
Nd	50	(b)			31.6	(d) 32	23	(b)	
Sm	18	(b)			13	(d) 6.3	11	(b)	
Eu	2.84	(b)			2.3	(d) 1.3	1.8	(b)	
Gd					19.6	(d)			
Tb	4.5	(b)				1.9	3	(b)	
Dy	29	(b)			22.6	(d)			
Ho									
Er					13.2	(d) 0.59		(b)	
Tm						1.5	0.63	(b)	
Yb	16	(b) 10	(c )		11.9	(d) 6.9	9.3	(b)	
Lu	2.2	(b)				1.1	1.5	(b)	
Hf	14	(b)				8.9	8.6	(b)	
Ta	2.6	(b)				1.4	1.8	(b)	
W ppb									
Re ppb									
Os ppb									
Ir ppb									
Pt ppb									
Au ppb									
Th ppm		0.3	(b)			1.7	0.44	(b)	
U ppm							0.31	(e)	
							0.12	(e)	

technique: (a) XRF, (b) INAA, (c) mixed, (d) IDMS, (e) radiation counting

**Table 2: Other pieces of Geophone Rock for comparison.**

	70136	70137	70138	70139	70145	70146	70147	70148	70155	70156	70157	Ave.	70135
reference	Ma79	Ma79	Neal90	Neal90	Neal90	Neal90	Neal90	Neal90	Neal90	Neal90	Neal90		Laul74
SiO <sub>2</sub> %			Warner79										
TiO <sub>2</sub>	11.3	12	12.5	13.1	13.5	13.1	13	12.5	12.4	13.4	13.4	12.7	13.8
Al <sub>2</sub> O <sub>3</sub>	11.1	9.2	8.5	8.3	7.8	7.6	8.4	8.1	10.2	9.5	9.8	9	7
FeO	17.2	18	17.9	17.6	19	19.6	17.9	18.2	17.2	18	17.1	18	21.8
MnO	0.218	0.226	0.24	0.23	0.256	0.255	0.231	0.237	0.232	0.239	0.237	0.24	0.27
MgO	9	10	8.2	9.6	8.5	8.8	8.8	8.8	8.7	9.8	9.1	9	9
CaO	10.1	10.3	9.5	10	9.2	9.7	9.2	9.7	9.6	10.5	11.1	9.9	8.7
Na <sub>2</sub> O	0.486	0.421	0.39	0.36	0.36	0.36	0.39	0.36	0.44	0.39	0.44	0.4	0.4
K <sub>2</sub> O	0.045	0.048	0.05	0.04	0.08	0.05	0.06	0.05	0.03	0.05	0.06	0.05	0.11
P <sub>2</sub> O <sub>5</sub>													
S %													
sum													
Sc ppm	72	77	77	80	82	85	77	79	72	82	77	78	82
V	128	132	134	143	130	126	131	132	130	149	136	134	120
Cr	3366	3654	3430	3810	3440	3450	3530	3720	3380	3910	3670	3580	3462
Co				19.8	26.2	18.4	21.6	22.8	21.6	21.3	21.6	19.3	21.4
Ni				4	31	19	5	6	9	78	42	39	26
Cu													
Zn													
Ga													
Ge ppb													
As													
Se													
Rb													
Sr				170	180	240		140	170	210	170	130	
Y													
Zr				230	160	180	250	210	110	130		170	
Nb													
Mo													
Ru													
Rh													
Pd ppb													
Ag ppb													
Cd ppb													
In ppb													
Sn ppb													
Sb ppb													
Te ppb													
Cs ppm				0.11	0.02	0.11	0.07	0.04	0.11	0.16	0.12	0.08	
Ba				65	67	103	104	76	67	35	65	82	60
La	4	4	5.1	3.1	6.2	6.3	4.8	3.7	3	3.1	4.4	4.3	12.6
Ce	15	17	24	13	32	29	22	16	12	14	16	19	52
Pr													
Nd	18	19	20	15	25	26	18	14	13	14	18	18	50
Sm	6.7	7	7.6	4.8	9.5	9.5	7.1	5.6	4.8	5.2	6.8	6.8	18
Eu	1.85	1.63	1.9	1.4	2.1	2	1.7	1.6	1.7	1.5	1.9	1.7	2.84
Gd													
Tb	1.6	1.6	2.1	1.5	2.4	2.7	2.1	1.5	1.7	1.6	1.9	1.9	4.5
Dy	11	11	15.8	9.7	18.5	17.4	13.2	11.2	10.5	11.3	13.4	12	29
Ho													
Er													
Tm													
Yb	6.2	6.6	7.5	5.4	9.2	9.4	7.2	6.1	5.3	5.6	6.8	6.8	16
Lu	0.85	0.93	1.12	0.81	1.35	1.33	1.07	0.92	0.78	0.85	0.99	1	2.2
Hf	6.7	6.7	7.3	5.7	8.7	8.8	6.9	6.2	5.4	5.6	6.7	6.8	14
Ta	1.4	1.5	1.6	1.2	1.7	1.8	1.4	1.4	1.2	1.2	1.4	1.4	2.6
W ppb													
Re ppb													
Os ppb													
Ir ppb													
Pt ppb													
Au ppb													
Th ppm				0.1	0.3	0.3	0.1	0.2	0.1	0.1	0.1	0.2	0.14
U ppm				0.2	0.1	0.5	0.1	0.1	0.3	0.2	0.1	0.2	0.14
technique: (b) INAA													

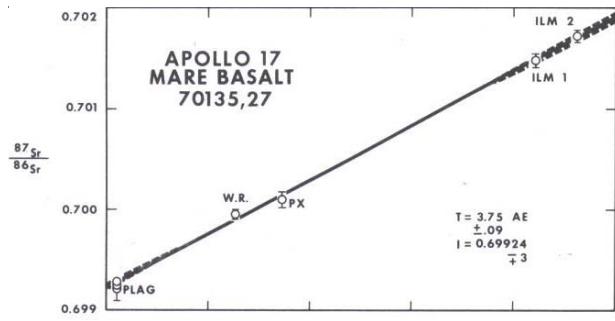


Figure 9: Rb - Sr internal isochron for 70135 (Nyquist et al. 1975).

### Summary of Age Data for 70135

	Rb/Sr	Sm/Nd
Nyquist et al. 1975	$3.75 \pm 0.09$ b.y.	
Nyquist et al. 1979		$3.77 \pm 0.06$
Paces et al. 1991		$3.71 \pm 0.12$

**Caution: Beware changing decay constants!**

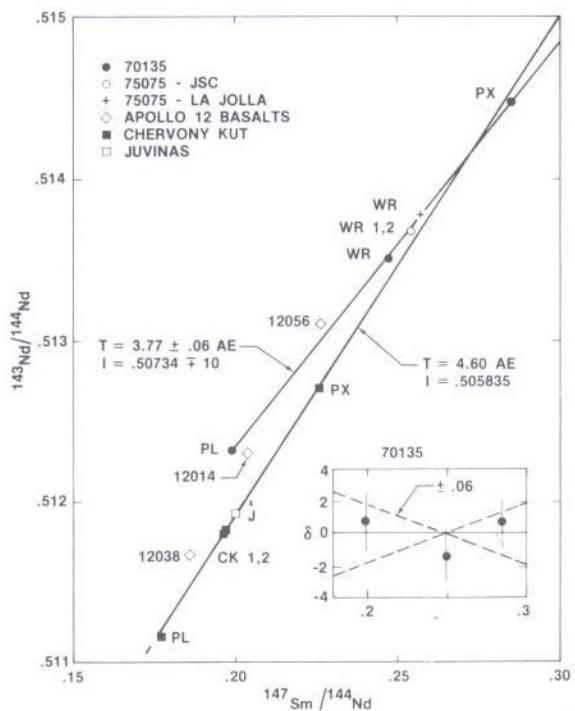


Figure 10: Sm - Nd internal mineral isochron for 70135 (Nyquist et al. 1979).

**Table 6**

	U ppm	Th ppm	K ppm	Rb ppm	Sr ppm	Nd ppm	Sm ppm
Eldridge 74	0.12		0.31				
Shih 75				0.82	186	31.6	13
Nyquist 75				0.82	186		
Nyquist 79						31.8	13
Paces 91				0.65	182	27.8	11.5
average small	0.14	0.14	500	0.28	146	12.3	5.3
Korotev 75						18	6.8
							6.5
							8.2

**Table 3: Other pieces of Geophone Rock**

	weight (g)
70135	446.3
70136	10.65
70137	6.16
70138	3.66
70139	3.16
70145	3.07
70146	1.71
70147	1.35
70148	0.92
70149	0.95
70155	0.77
70156	0.63
70157	0.57

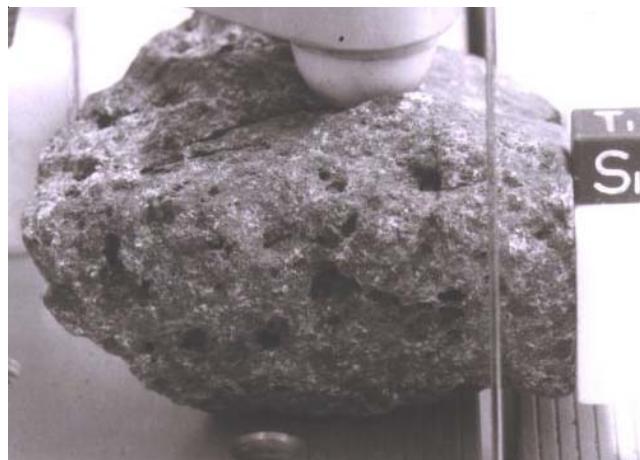
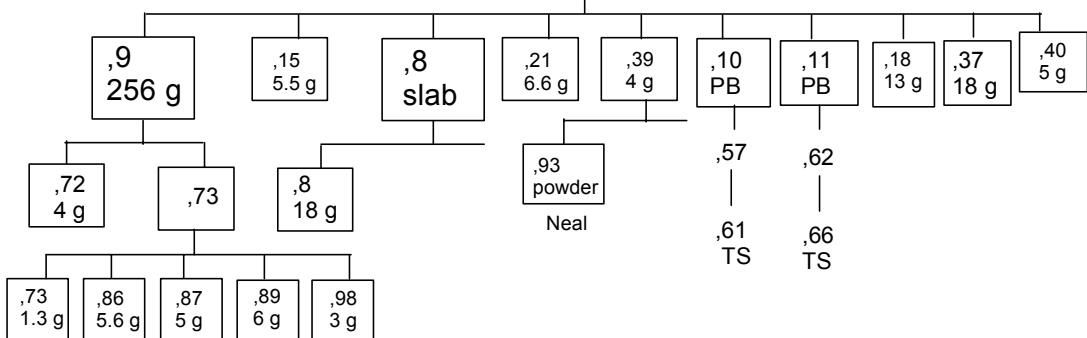


Figure 11: Processing photo of 70135 showing second cut used to prepare slab. Cube is 1 cm.

**70135**  
**446.3 grams**



### References for 70135

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